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Technological changes, building national innovation system and instruments for developing networks and cooperation in Russian Federation*

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Direction of technological changes and innovation development are very actual issues, especially in post-socialist space. Main tendency in innovation policy in recent time is coming down to regional level of directing innovation processes. And the process of technological changes is understood as multi-level and multi-factor process. On this basis some problems and tendencies in Russian innovation sphere are considered in this paper. Several mechanisms and instruments of innovation policy on different levels of integration are discussed.

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1. Different approach for innovation and technology changes analysis

Last decades innovation became a key aspect of economic development and competitiveness. And the main challenge for developing as well as for developed countries today is to create the conditions for improving of innovativeness of firms within the country. Innovation is a complex and multi-branch conception, concerned with different actors, institutes and organizations, which interact between each other and constitute innovation system. The main elements of innovation system are firms, universities, research organizations, mediating companies and government. In this system firms get new knowledge and use it for developing new products. Such knowledge flows proceed due to networks appearing between system's elements. And in this process government and state organizations can play an important role, forming a structure of innovation system via financial incentives, setting rules, changing environment, establishing priorities, building up research excellence, providing higher education etc.

Initially conception of innovation system referred to national level, but uniform innovation policy held on national level, especially in large countries, does not often take into account features of region development, and therefore is not efficient. We can observe that socio-economic process in the world today proceeds in two interrelated directions: globalization and regionalization. It means that on the one hand firms can freely allocate their technological chains around the world, but on the other hand they do it in the first place in such regions, which posses the best competencies, the best resource and the best conditions for development. That is why processes of building of innovation systems are shifting from national to regional level and conception of regional innovation system (RIS) as subsystem of NIS has appeared. RIS, in turn, consists of networks and subsystems, and clusters are among them. Network interactions inside RIS or cluster can be provided by specialized organizations, such as transfer technology centers or cooperation centers.

In addition studies in areas of technological changes and innovation development has led to appearing of conceptions of technological systems, clusters, multi-level perspective of technological transition, knowledge-based economy. And these conceptions aim to understand and to explain source of innovation, ways of knowledge diffusion, processes being in technological structure of economy in different levels, changing in networks of innovation actors.

And if conception of innovation system refers to the national features of innovation performance, technological systems can cross national boundaries and be considered as independent structure. In the broad sense innovation system is the network of actors linked between each other and that generate,

diffuse and use innovation. Similarly technological system an be defined as “network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilization of technology” (Carlsson and Stankewicz, 1991, p.111). Such technological system can be also considered from sectoral or product point of view, and limited by region sectoral system can begin a basis of cluster.

There are a lot of definitions of these conceptions and different scholars approach to description of these systems by different ways. But several features are inherent in these kinds of economic systems. We can distinct the follow ones.

a) Systems consist of innovation actors and institutions, which integrate into innovation networks. There is a set of rules, which regulate an interaction within the network and existing this network and special relations define an efficiency of the whole system.

b) Such systems in their performing pursue the realization of certain functions, which are carries our by different innovation actors. Carrying out the functions, activities of innovation actors are interrelated with changing in the system and achievement the main goals of the system, which are the diffusion of knowledge and the creation of innovation.

c) System is characterized by certain technological structure and direction of technological changes. It also defines sectoral or product specialization.

d) Technological and institutional changes proceed on different levels of integration, including the level of firms, the level of technological systems and regimes and the macro-level of external environment.

From different point of view on technological changes and innovation networks we can distinct several kinds of systems consisted of various actors and carrying out different functions. Of course these systems have similar elements and it is important to delineate them, because this issue matters not only in theoretical sense, but for applied economic policy. It means that government has to coordinate goals and instruments of different sphere of economic policy including innovation policy, science and technology policy, industrial policy etc.

As to technological aspects theories of technological changes are developed very intensively in western studies as well as in Russian scientific thought. In Russia the conception of technological structure is widely used. Glaziev, Yakovetc examined how horizontal and vertical links between technologically depended elements build technological chains and systems of technological networks (Glaziev, 1993; Yakovetc, 1998). Rosenberg, Dosi, Geels developed conceptions of technological regimes, trajectories.

With the lapse of time technology is improved and in the process of diffusion different technologies interact between each other. It was the case with the steamship of Robert Fulton, who coupled two technologies – steam power and boat. Technologies can't exist separately in economy and the faster science and technology progress the more intensive interdependency of different technologies. Value-added chains are getting longer.

Considering some industry from product point of view it is very difficult to follow technological changes, because one industry can exist during a long period of time, but production base and process can be considerably changed. Technological processes proceeded in any industry are inter-industry processes and changing in one part of a chain leads to changing in other parts and industries. Usually industry is very heterogeneous and consists of chains and productions characterized by different technological level. For example, Aircraft production includes production of engine, materials and other parts. And to produce these components certain technological chains have to be built, and these chains can be followed up to row materials mining. And the technological level of these chains defines the level and quality of final product.

Therefore technological chains and included production and other actors can create special technological systems, characterized by certain rules, skills, practices etc, that make this system separated from other ones. This kind of system Rip and Kemp called technological regime and defined as "the grammar or rule set comprised in the complex of scientific knowledge, engineering practice, production process technologies, product characteristics, skill and procedures, and institutions and infrastructures that make up the totality of a technology" (Kemp et al., 2001, p.272).

Considering technological structure and technological regimes it is very important to follow mechanisms these systems evaluate. And example of instrument of analysis is conception of multi-level framework of technological transitions (Geels, 2002: Markard et al, 2006). This multi-level framework explains the process of technological changes at three levels: micro-level, meso-level and macro-level.

The meso-level is the level of technological regimes, which are the stable structure with established products and technologies, stocks of knowledge, user practice, expectations, norms, regulations, etc. In addition technological regime is environment where innovation is fostered in certain field, but where there are hard barriers for radical innovation from external sources.

The micro-level is represented by firms that develop radical innovation these firms are protected from regime by special niches. They establish the base of micro-level. "A niche can be defined as a discrete application domain (habitat) where actors are prepared to work with specific functionalities,

accept such teething problems as higher costs, and are willing to invest in improvements of new technology and the development of new markets" (Hoogma et al., 2002, p.4).

The macro-level in this framework is closely related to the conception of long-run cycles by Kondratiev (Kondratiev, 2002). The macro-level or landscape consists of independent factors and events which can influence on regime and on hardness of its barriers and correspondingly on opportunities for radical innovation fostered by firms. It is a "set of heterogeneous factors, such as oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values, environmental problems" (Geels, 2002, p.1260).

For example we can see that majority of modern automobile uses gasoline engine and there is special infrastructure for serving automobiles and technological chains are built for production this type of engine. But we know that there are alternative technologies for moving vehicles: biofuel, electricity. But these technologies take niches and can't change prevailing technologies in short terms. But such external factors as oil prices can open some opportunities for niche firms what allow to diffuse innovation inside the regime. In addition these niches and opportunities can be created by government which provides special policy and gives some incentives (financial incentives, law incentives and restrictions, supporting programs, investments etc).

Therefore innovation and technological development are multifaceted and its study leads to appearing of different conceptions. These conceptions describe activities on different levels and the important goal of theoretical discussion and real economic policy is to practically delineate boundaries of different systems and to find places where it is possible to influence on them.

2. Innovation system in Russia and instrument for its improving

As it was mentioned above innovation process proceed on different levels. To describe features of innovation policy and technological changes in Russia we consider that innovation process in the country proceeds on follow levels of integration:

- National innovation system
- Regional innovation systems
- Clusters
- Networks
- Organizations

And innovation policy in Russia tends to be held according to this structure. Last time main government activity comes down from national level to regional taking in account features of development

of local environment, business, education, non-commercial organizations. Considering regional innovation systems in Russia we can take as basis the follow model (see Fig 1)

Thus RIS consists of two main parts: knowledge generation and diffusion subsystem; knowledge application and exploitation subsystem. The first block contains such elements as technology and workforce mediating organizations, research and educational organizations and these institutions produce and diffuse knowledge and skills. Companies, their clients, collaborators, competitors and horizontal and vertical networks appeared between them make up the second subsystem. These elements usually form industrial clusters of regions. Subsystems are embedded into regional socioeconomic and culture settings. In addition RIS actively interacts with external elements and institutes of national innovation system, other RIS, international organizations and these links are very important for sustainable development of RIS.

Innovation processes in different levels in Russia are very weak. And the main areas where Russia has problems are:

- Strategy deficiency
- Function dividing
- Information access
- Monitoring

Strategy deficiency

There is no long-run innovation strategy, which would fully describe goals, tools and mechanisms of innovation development. During the last fifteen years a lot of government programs in innovation and technology areas have been provided, but these programs had mainly short-run character and were inconsistent. Therefore one of the most important goals of government policy – to make priorities in innovation and technological development – was not carried out and innovation policy in general was not systemic. In addition this problem consists in deficiency of instruments of direction, weak legal foundation of innovation activities (for example, lack of such definition as innovation, technology and high technology sector, weak patent law), problems with interaction between regions and innovation actors. Another aspect is that different kinds of economic policy (innovation, industry, cluster, technology) are not delineated and their goals are not interconnected. As consequence there are no sufficient results in innovation sphere.

Function dividing

There are a lot of innovation functions that have to be divided between different elements of innovation system. The set of functions can be carried out by certain organizations. The first aim of innovation policy in this area is to define competencies of national and regional governments. The second aim is to match functions with relevant organizations and create conditions for better performance of these organizations. Both aims are not realized so far in Russia and this process depends to a large extent on political disagreements.

Function approach in building innovation system allows to solve the problem of integration of different innovation elements into the common environment and to find the place of each element in innovation structure. Previous government policy consisted in the chaotic coping institutes from developed countries and creation of such organizations as scienceparks, venture funds, business incubators etc. Therefore innovation system was just a set of elements without links and relations between them. And the main goals and functions these elements were called to carry out such as knowledge transfer, diffusion of innovation, were not achieved. But from functional point of view certain organizations of a system have to hold certain activities providing efficient realization of innovation functions.

Information access

Access to information and information dissemination in Russia are very limited. It means that it is very difficult or even impossible to get certain documents through such source as Internet, for example, and decision-making process in state organizations is closed for the most part of concerned actors. This fact hampers innovation process in the country.

Monitoring

This problem is closely related to formulating strategy and its aims and also with lack of legislation. There are not real indicators by which efficiency of program can be evaluated. Therefore it is very difficult to control carrying out of programs and their results.

Certainly, there are other problems in innovation sphere in Russia, but mentioned system failures in Russian innovation policy have to be overcome in the first place. For solving these problems several instruments and government programs are being developed by Ministry of Economic Development (MED), Institute of Regional Innovation Systems (IRIS), other actors and also with participation of foreign experts.

Corresponding levels of forming innovation processes in the country there are follow mechanisms and instruments:

- Federal Program for Building and Development of Regional Innovation Systems in Russian Federation (developed by IRIS)

- Program of Building Clusters in Regions of Russian Federation (developed by MED)
- Building of network of international cooperation centers for knowledge and technology transfer
- Specialized instruments and initiatives of regional level, developed by local governments

The main goals of these instruments are to provide integration between different levels of innovation activity (including NIS, RIS, clusters, cooperation centers),d to incorporate regions into international networks and to stimulate innovation process from bottom as well from top.

Federal Program for Building and Development of RIS is being developed by Institute of Regional Innovation Systems and will include the main instruments of innovation development on regional level. Among these instruments there are regional centers of expertise, which can carry out functions of directing innovation process, information providing, project evaluation. Also this program contains list of innovation functions and mechanisms of their realization. Goals of this program are being coordinated with goals of other government documents, such as “Strategy2020”. Corresponding to international experience it can be considered follow functions provided in innovation process (table 1).

Therefore this program provides instruments for building efficient interaction between different levels of authority dividing function and responsibility between central government and regional governments. In addition the goal of the program is to delineate places which different innovation actors (business, academia, non-profit organizations, organization of infrastructure, government) take in innovation system and efficient networks are planned result of this work.

As an example of regional activity Saint-Petersburg city, the north-west metropolitan area of Russia, can be considered. And innovation processes proceed in this region in several directions, including cluster building and development of regional and international integration.

As to cluster formation in Saint-Petersburg we can observe the follow structures and tendency in the St.-Petersburg manufacturing (Figure 2).

There are several branches that have a good potential to development and characterized by high level of market attractiveness, clustering potential and innovation potential. The leading branches are: instrument building (including aircraft industry, electronic and radio industry), shipbuilding and power machinery, represented by such companies as “Power machines”, “Aerospace equipment corporation”. Firms in these sectors are competitive in the world market and take the big share of market in several segments. In the shipbuilding sector government creates state-run company “United shipbuilding corporation”, which’s goals are to consolidate assets in this sector and to develop civil shipbuilding along

with war shipbuilding. St.-Petersburg is the center of shipbuilding and there are three shipyards in the city, but there are several problems in the industry and inefficient technological chains and weak management are among them.

Railway equipment building and electrical industry are in the next group of branches, and development of these sectors depends to a large extent on government policy and government order. It is the case with the electrical industry, which can be developed by such mechanism as placing the government order on digital television equipment production, since firms in this sector posses required technologies to produce this equipment. And government program Development of digital television in Russian Federation can provide this opportunity.

In general there are several problems in technological development in Russia. And among them we can find the problem of embedding of big state-run corporations into technological chains, the problem of innovativeness and technological improvement of these companies, the problem of impossibility to integrate small innovative firms into a system of suppliers of big and medium companies, what influence on development of competition in Russia and also lead to collaboration small and medium hi-tech firms mainly with foreign partners.

Big state-run corporations play an important role and take a big part of Russian economy and therefore it is very important to find mechanisms of efficient interaction between these companies and other agents. Among these corporations there are “United shipbuilding corporation”, “United aircraft corporation”, “Russian railways”, “Gazprom” etc. They form big set of suppliers and services organizations, which, in turn, cooperate and interact with great amount of agents. These links form long technological chains including R&D, production and delivering of components, building up equipment, service etc. As consequence a pyramid can be build with big corporation on the top and with a great deal of firms at the bottom.

Behavior of big corporation depends on different factors including state standards, competition, and demand. In these terms corporations can correct their long-run strategy planning use certain technologies in their activity. And these signals influence on strategy of other agents in technological chains.

But the problem is that strategy of state-run corporations is not formalized it is mainly because of absence of strong government regulation of big corporations. In addition different technological standards and limitations are not actively used.

On the level of corporations the process of directing technological chains is neglected what lead to hardness of these chains and complications for innovative firms to be embed into chains. It is the case,

for example, with small nanotechnology firms, which can't find market for their product and technologies in Russia.

On the level of innovation actors and participants of clusters and regional systems solving problems of integration can be provided by specialized organizations, and Saint-Petersburg Innovation and Technology Center ITZ, which is being under developing at the moment, can be an example of regional networking on the one hand and international cooperation on the other hand. ITZ Center project is the result of the Russian-German collaboration and its initiators were:

- IMC/HM International Project Management
- IRIS
- Russian-Germany "Institute of Polymers"

And Bavarian government, German East Forum, Technical University Munich were the main partners.

Key investors of this project are:

- Technischer Überwachungsverein Bayern Süd (TÜV Süd) (world leader in sertification)
- World Trade Center (WTC)
- Siemens
- Daimler AG
- Erlangen AG – net of technoparks in Germany
- Investment group CATELLA

The ITZ St. Petersburg addresses two directions of effects:

- Outbound-activities: ITZ St. Petersburg helps innovative Russian SMEs to get into the European market, to find the right cooperation partner or to license their products.
- Inbound-activities: ITZ St. Petersburg speed-up the market-entrance-period of innovative European companies to enter the Russian market.

Therefore the innovation and technology center aims to help German and Russian firms to perform more effectively in foreign markets, using experiences, technologies, potential of science and industry of Russia and Germany.

ITC (Figure 3) will allow different innovation actors to get access to information about the innovation process in Russian and foreign clusters, and also this center can play the role of the instrument of the integration of state-run companies into the process of development and dissemination of new technologies. Similarly, Russian nanotechnology corporation "RusNano" plans to build the similar

center in St-Petersburg as the basis for development cooperation in nanotech sphere. And this issue is very important, because state-run corporations in Russia play an important role in the Russian economy, taking big market shares in different sectors.

The main focus of activities ITZ:

The ITC will be the Center for Technology - Transfer, for the foundation of the innovative clusters of different industries, which are primary:

- Engineering
- Metalworking
- New materials and Plastics (e.g. polymers, composites and others)
- Training and Certification
- Others (still to be defined according to the needs of Russian demand)

Therefore regional and federal governments and innovation actors develop different instruments for building in regions innovation milieu. This processes are still in initial states, but we expect that Russian innovation sphere will perform more effectively and further international cooperation will be more intensive.

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Figure 1. Main structure of regional innovation systems. (Modification of Autio (1998), p.134

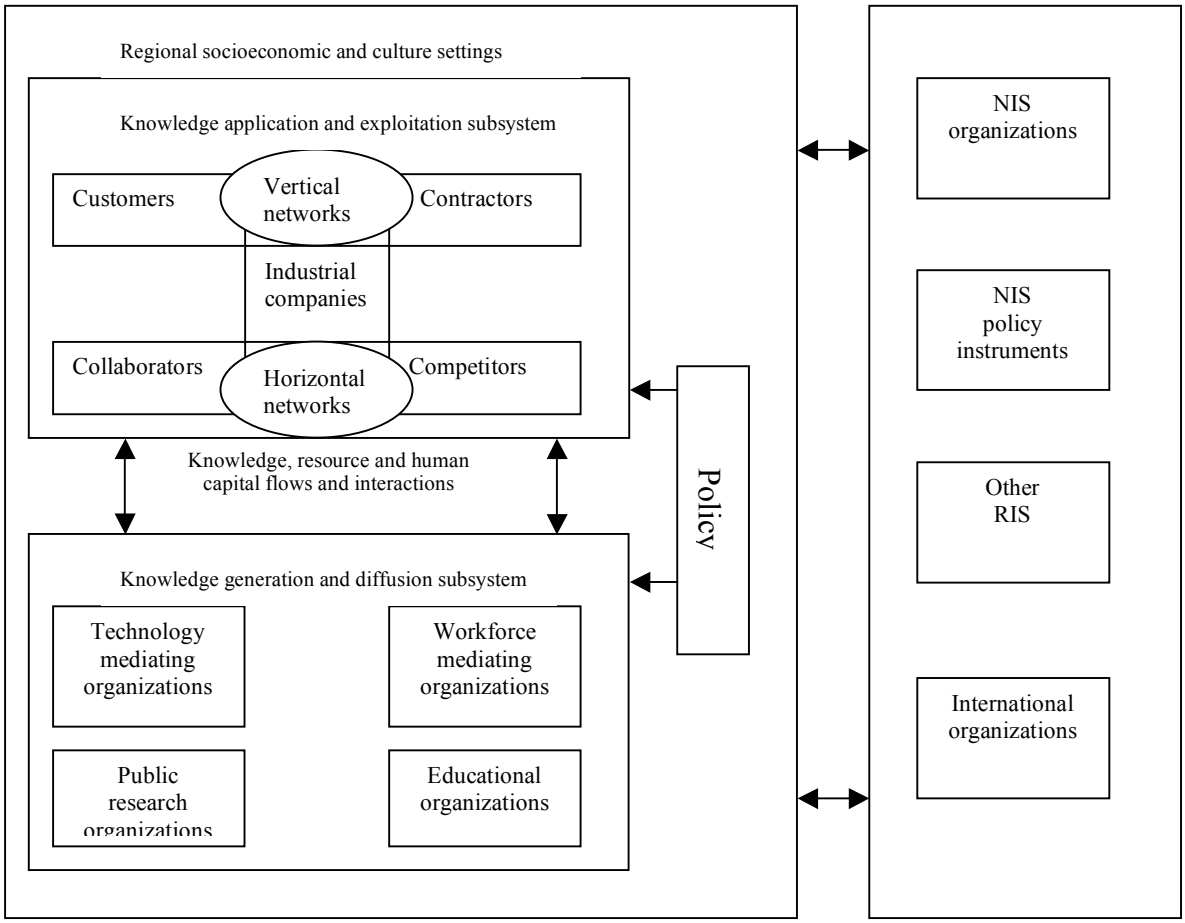
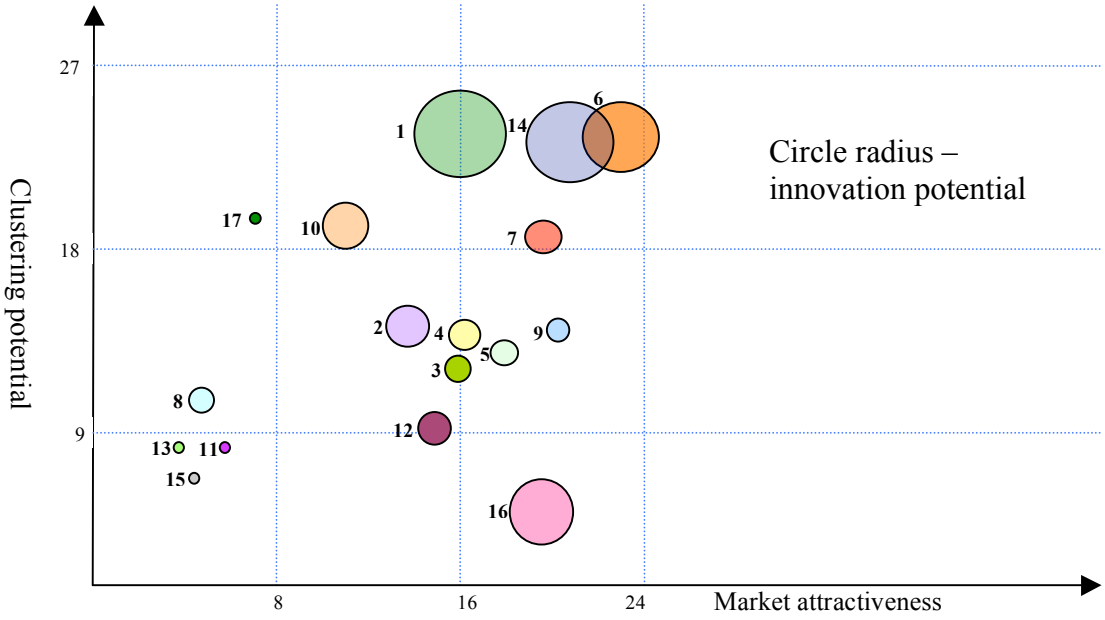


Table1. Innovation functions

Functions	Activities	National level	Regional level
Analisys	Benchmarking	International Benchmarking	Specific regional benchmarking
	SWOT		Regional level
	Foresight	National foresight	Regional foresight
	Technological assessment	General Technological assessment	Regional Technological assessment
Initiation	Development of programs and strategies	National level	Regional programs
	Diffusion of efficient practices		Regional level
	Building alliances	International alliances	Regional level
	Start new innovation projects	National level	Regional level
Legislative	Legislative control	National legal system	Local initiatives
	Standartisation	National standards	
Information	Diffusion of information	National structure	Regional structure
	Building national and inter-regional forums	National level	Regional level
Consulting	Creating manuals for development of innovation systems	National level	Regional level
	Expertise	National institutes	Regional organisations
	Education, professional development, training	National level	Regional level
	Training for policy-makers		Regional level
	Supporting KIBS		Regional level
Support	Financial incentives	National financial institutes	Regional capital
	Tax remissions	National level	Local incentives
	Support programs for innovation firms	National programs	Regional programs
	Support of customer and suppliers	National programs	Direct contact with firms
	Development of innovation institutes	NIS	RIS
Management, coordinating and mediating	Creation of innovation networks	International and inter-regional networks	Regional networks and cooperation
	Project management		
	Creating knowledge infrastructure	Common infrastructure	Specialized infrastructure, regional demand on knowledge
	Realization of government programs	National level	Regional level
	Human capital management	National programs	Direct contact with organizations
	Organizational improvement, using informational technologies	National programs	Direct contact with organizations
Monitoringr	Development of programs of	National level	Regional level

	evaluation		
	Monitoring and estimation of results	National level	Regional level
	Changing the strategy	National level	Regional level

Figure 2. Clustering in manufacturing industries



(1) Instrument making industry, including aircraft industry, electronic and radio industry
(2) Computers, office machinery
(3) Pharmaceuticals
(4) Medicine instruments
(5) Machine-tool construction and engineering
(6) Power machinery
(7) Electrical industry
(8) Diesel engine building
(9). Agricultural engineering
(10) Railway equipment building
(11) Transport machinery
(12) Chemical and oil equipment
(13) Road construction, municipal engineering
(14) Shipbuilding
(15) Textile industry
(16). Food, beverages and tobacco
(17) Wood and furniture

Figure 3. The main services of ITC and their target groups